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Determining Soil Organic Matter Composition and Decomposability across the Permafrost Region Using Mid-infrared Spectroscopy

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Soil organic matter (SOM) turnover and stability are largely controlled by environmental and biological factors; however, the chemistry of SOM can also be an important influence on decomposition and soil respiration. In permafrost regions, organic matter is often preserved in a relatively undecomposed and uncomplexed state, both in surface horizons and in buried forms such as peat deposits and cryoturbated organic matter. Because of the large amounts of SOM stored in these soils and differences in the relative importance of SOM stabilization mechanisms operating in the permafrost region compared to other soil types, the composition and potential decomposability of SOM are key uncertainties in models assessing the amount of carbon that might be released from this region. We have demonstrated that mid-infrared (MIR) spectroscopy can provide valuable information to characterize the chemical composition of permafrost-region SOM and its potential decomposability. MIR spectra can be related to many soil attributes including carbon and nitrogen concentrations, land cover type, parent material, pH, and other chemical and physical properties. Furthermore, MIR is very sensitive to the degradation state of SOM, and it is a good predictor of the short-term carbon mineralization potential of tundra soils. We are applying MIR spectroscopy techniques to soils collected by numerous investigators in Alaska, Canada, Greenland, and Russia to create a Soil-IR library of MIR spectra that will enable widespread estimates of SOM composition and potential decomposability across the permafrost region. Using the Soil-IR library, we investigated multivariate relationships between soil properties and MIR spectra that have yielded robust calibrations. We are now exploring the applicability of these calibrations to numerous other archived samples. We have also studied SOM stability indicators of SOM decomposition and maturity using MIR organic functional groups and mineral signature ratios across gradients of climate, vegetation type, and other soil- forming factors. The ultimate goal of our research is to link estimates of SOM composition and potential decomposability with geo-referenced data characterizing soil properties and environmental conditions to create geospatial assessments and maps, which can serve as benchmarks for models at landscape, regional, and global scales.